Micro Solid-State Photonics

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Education

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Professional Employment

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1989 Research Associate, Fukui University
1993 Visiting Researcher, Stanford University (–1994)
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Awards

2004 Persons of Scientific and Technological Research Merits, Commendation by Minister of Education, Culture, Sports, Science and Technology, Japan
2010 OSA Fellow Award, The Optical Society (OSA)
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"*Micro Solid-State Photonics*," based on the micro domain structure and boundary controlled materials, opens new horizon in the laser science. The engineered materials of micro and/or microchip solid-state, ceramic and single-crystal, lasers can provide excellent spatial mode quality and narrow linewidths with enough power. High-brightness nature of these lasers has allowed efficient wavelength extension by nonlinear frequency conversion, UV to THz wave generation. Moreover, the quasi phase matching (QPM) is an attractive technique for compensating phase velocity dispersion in frequency conversion. The future may herald new photonics.

Giant pulse > 10 MW was obtained in 1064nm microchip lasers using micro-domain controlled materials. The world first laser ignited gasoline engine vehicle, giant-pulse UV (355 nm, 266 nm) and efficient VUV (118 nm) pulse generations have been successfully demonstrated. Also, few cycle mid-IR pulses for atto-second pulses are demonstrated by LA-PPMgLN. We have developed new theoretical models for the micro-domain control of anisotropic laser ceramics. These functional micro-domain based highly brightness/brightness-temperature compact lasers and nonlinear optics, so to speak "Giant Micro-photonics," are promising. Moreover, the new generation of micro and/or microchip lasers by using orientation-controlled advanced ceramics can provide extreme high performances in photonics.

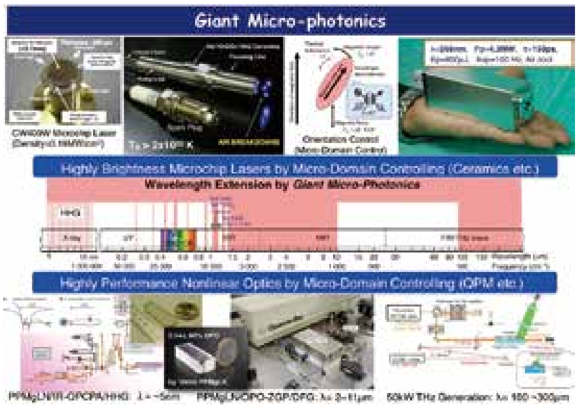

Figure 1. Giant micro-photonics.

Selected Publications

- H. Sakai, H. Kan and T. Taira, ">1 MW Peak Power Single-Mode High-Brightness Passively Q-Switched Nd^{3+}:YAG Microchip Laser," *Opt. Express* **16**, 19891–19899 (2008).
- M. Tsunekane, T. Inohara, A. Ando, N. Kido, K. Kanehara and T. Taira, "High Peak Power, Passively Q-Switched Microlaser for Ignition of Engines," *IEEE J. Quantum Electron.* **46**, 277–284 (2010).
- T. Taira, "Domain-Controlled Laser Ceramics toward Giant Micro-Photonics," *Opt. Mater. Express* **1**, 1040–1050 (2011).
- H. Ishizuki and T. Taira, "Half-Joule Output Optical-Parametric Oscillation by Using 10-mm-Thick Periodically Poled Mg-Doped Congruent $LiNbO_3$," *Opt. Express*, **20**, 20002–20010 (2012).
- R. Bhandari, N. Tsuji, T. Suzuki, M. Nishifuji and T. Taira, "Efficient Second to Ninth Harmonic Generation Using Megawatt Peak Power Microchip Laser," *Opt. Express* **21**, 28849–28855 (2013).

1. Anisotropic Yb:FAP Laser Ceramics by Micro-Domain Control

Highly transparent Yb:FAP fluorapatite (FAP) ceramics were realized by use of slip casting under rotational magnetic field of 1.4 T from a electromagnet, even though the main crystal axis become a hard magnetization axis. This means that the enhancement of magnetic anisotropy by rare-earth doping is also effective for the orientation control even under the rotating magnetic field. X-ray and optical evaluations clearly gives the first evidence that our Yb:FAP ceramics have a laser-grade quality in the world. We confirmed the laser-grade quality of Yb:FAP ceramics by inserting into a lasing cavity with Nd:YVO_4 as a gain medium: It did not interrupt laser oscillation.

Currently well-aligned anisotropic laser ceramics can be produced by only the orientation control by slip-casting under the magnetic field, therefore our methods should be the solution for appreciating advantages of anisotropic laser gain media and ceramic gain media, simultaneously.

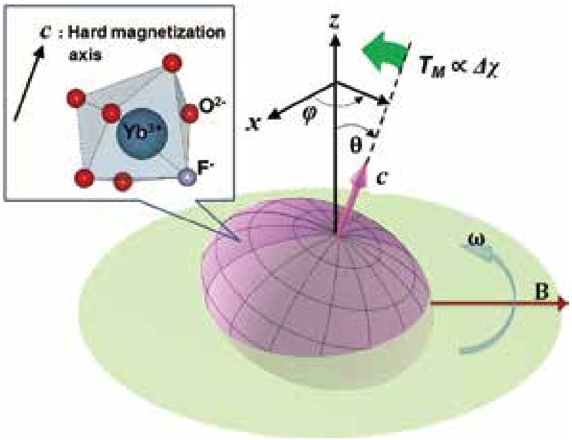

Figure 2. Schematic diagram for the spheroidal of magnetic energy of the processed particle under the rotating magnetic field. This particle is made of FAP doped with Yb^{3+}, of which main crystal axis is hard magnetization axis.

2. Compact Megawatt Peak Power 266 nm Laser at 1 kHz

Compact and stable megawatt peak power 266 nm laser at 1 kHz from sub-nanosecond passively Q-switched laser was demonstrated. In order to optimize thermal management and obtain stable UV laser operation at high repetition rate 1 kHz, we put forward to increase pump efficiency by employing higher pump power laser diode while maintaining the low depolarization ratio by fixing specific angle between <110>-cut Cr:YAG and <100>-cut composite YAG/Nd:YAG crystal. Megawatt peak power UV laser (266 nm) at 1 kHz is important for developing Time-of-Flight Mass Spectrometer with the technology of Single Photon Ionization (SPI).

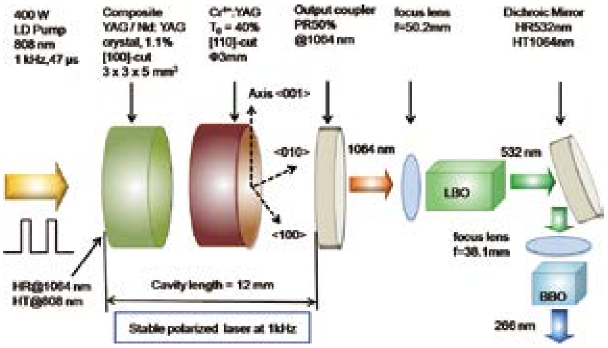

Figure 3. Schematic diagram of 266 nm laser at 1 kHz.

3. Optical Parametric Mid-Infrared Generation Pumped by Sub-Nanosecond Microchip Laser

Single-pass Mid-infrared optical-parametric generation (OPG) pumped by microchip laser with sub-nanosecond duration was demonstrated. Effective single-pass OPG with 1 mJ output energy using conventional PPMgLN could be realized. Broadband single-pass OPG could be also realized using chirped PPMgLN.

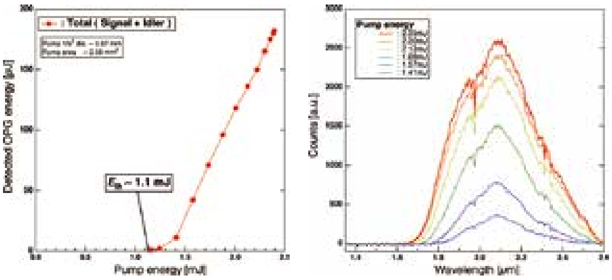

Figure 4. (a) OPG output on input pump energy, (b) OPG spectrum on various pumping energy, using a chirped PPMgLN.

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1) Y. Sato and T. Taira, *Opt. Mater. Express* **4**, 2006–2015 (2014).
2) T. Taira, A. Kausas and L. Zheng, *Nonlinear Optics (NLO2015)*, NTu3B.2 (July 26–31, 2015).
3) H. Ishizuki and T. Taira, *The 62nd JSAP Spring meeting 2015*, 13a-A13-3 (Mar. 11–14, 2015).